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Serial No.: 10/050,639

Confirmation No.: 6476

Filed: January 15, 2002

For: METHOD AND COMPOSITION FOR SELECTIVELY ETCHING AGAINST COBALT SILICIDE**Remarks**

The Office Action mailed May 29, 2003 has been received and reviewed. Claim 60 has been amended. No other claims have been amended or cancelled. Therefore, claims 46 and 51-88 are pending in the present application. Reconsideration and withdrawal of the rejections are respectfully requested

I. Whether claims 46 and 51-59 are patentable under 35 U.S.C. § 103(a) over Hayashi et al. in view of Berti et al.

The Examiner continues to reject claims 46 and 51-59 under 35 U.S.C. § 103 as being unpatentable over Hayashi et al. (U.S. Patent No. 5,482,895) and further in view of Berti et al. (U.S. Patent No. 5,567,651). Applicants respectfully traverse the Examiner's rejections.

To establish a *prima facie* case of obviousness, three basic criteria must be met. First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings. Second, there must be a reasonable expectation of success. Finally, the prior art references must teach or suggest all the claim limitations. See M.P.E.P. § 2143.

Claim 46 recites a method of selectively etching a portion of a metal nitride region against a cobalt silicide region using a solution including a mineral acid and a peroxide, wherein the solution etches the portion of the metal nitride region at an etch rate in a range of about 50 Å/minute to about 250 Å/minute.

The Examiner recognizes that Hayashi et al. does not describe a solution containing a mineral acid to etch TiN, e.g., a metal nitride described therein. However, the Examiner alleges Berti et al. teaches a method of etching metal nitride and cobalt using an etchant containing a mineral acid, such as phosphoric, acetic, and nitric acid, and further containing hydrogen peroxide.

The cited references do not teach or suggest all of the elements of claim 46, and therefore, claim 46 is not obvious in view thereof. As recognized by the Examiner on the top of

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page 3 of the Office Action, Hayashi et al. does not teach the etch rates for selectively etching metal nitride against cobalt silicide as described in claim 46 (i.e., 50 Å/minute to about 250 Å/minute). It is believed that the Examiner meant Berti et al. does not teach such rates as Hayashi et al. does not even teach the use of a mineral acid and peroxide solution to etch the metal nitride. However, the Examiner alleges that "the etch rate of the metal nitride depends on the chemical concentrations, which would be result-effective variables, in the solution in which the concentration would have to be determined through test runs in order to achieve the optimum chemical concentration in the solution to etch the metal nitride with an expectation of a reasonable success."

Claim 46 as stated above includes a solution that etches the portion of the metal nitride region at an etch rate in a range of about 50 Å/minute to about 250 Å/minute. Also as stated above, Hayashi et al. is silent regarding etch rates. The addition of Berti et al. does nothing to correct this deficiency already present in Hayashi et al. In fact, the etch rates of Berti et al. teach away from using higher etch rates, especially considering the Examiner's suggestion that the solutions can be diluted with deionized water (see page 3 of Office Action last paragraph).

Although Berti et al. does not explicitly teach etch rates, at least a general understanding of such etch rates can be discerned from the given information in Berti et al. Applicants continue to submit that such implicit etch rates disclosed in Berti et al. cannot be ignored, and that the cited references must be viewed in their entirety. As such, in view of the etch rates described in Berti et al., and their inapplicability to Hayashi et al., claim 46 is not *prima facie* obvious in view of the cited references.

In other words, Berti et al. teaches removing unwanted cobalt and titanium nitride by immersing the wafer for 30 minutes in a mixture of phosphoric, acetic, and nitric acids and hydrogen peroxide. The thickness of the titanium nitride layer prior to silicidation is 50 to 150 Å. See Berti et al., column 3, lines 24-26. The thickness of the cobalt layer prior to silicidation is 165 to 300 Å. See Berti et al., column 3, lines 17-18. If the entire described thickness of TiN and Co were considered (i.e., 450 Å), the etch rate for both thicknesses would only be 15 Å/minute. However, it is indicated that at least a portion (and usually a substantial portion to reduce the

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amount of unreacted Co to be removed) of the Co is consumed during the silicidation process. Therefore, the 15 Å/minute rate is clearly much lower. As such, Applicant continues to argue that Berti et al. does not show the etch rates described in the pending claims and actually shows rates that are much lower than the claimed rates used according to the present invention. Further, the etch rates of Berti et al. lead away from a method using higher etch rates, especially considering the Examiner's suggestion that the solutions are to be diluted with deionized water (see page 3 of Office Action last paragraph).

As stated in MPEP Section 2141.02, when dealing with obviousness type rejections, the Examiner must consider a prior art reference "in its entirety, i.e., as a whole, including portions that would lead away from the claimed invention." Such disclosed etch rates of Berti et al. cannot be ignored, especially considering the large difference between the etch rates disclosed and the etch rates claimed.

For at least the above reasons, claim 46 is not obvious in view of the cited references. Further, claims 51-59 are not *prima facie* obvious in view of the cited references for the same reasons by way of their dependency on claim 46.

Further, claims 51-59 recite additional elements that further support patentability when combined with claim 46. For example, claim 53 recites that the solution includes a ratio in a range of about 1:1:35 (mineral acid:peroxide:deionized water) to about 1:1:5 (mineral acid:peroxide:deionized water). As admitted by the Examiner, neither Hayashi et al. nor Berti et al. teaches solutions that include deionized water. However, the Examiner alleges that it would have been obvious to one of skill in the art to dilute the solution with an appropriate amount of deionized water, creating a concentration of mineral acid and peroxide that would optimize the removing process of metal nitride and cobalt against the cobalt silicide. Applicants traverse this allegation and submit that Berti et al. teaches away from this alleged motivation when considering the etch rates claimed.

In other words, the Examiner continues to assert that (as generally summarized by the Applicant) using deionized water to prepare any solution would be obvious and that routine experimentation would provide the etching rate claimed. However, as stated above, Berti et al.

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teaches an etch rate for titanium nitride that is much lower than the claimed etch rate. Diluting the solution taught by Berti et al. with deionized water, as is suggested by the Examiner, would cause the etch rate for titanium nitride to decrease, thereby becoming even further slower than the etch rate recited. Therefore, one skilled in the art would not be motivated to dilute the solution taught by Berti et al. to provide the present invention. The Examiner continues to fail to address such lack of motivation.

For at least the above reasons, Applicants submit that claims 46 and 51-59 are not *prima facie* obvious in view of the cited references. Reconsideration and withdrawal of this rejection are, therefore, respectfully requested.

II. Whether claims 60-67 are patentable under 35 U.S.C. § 103(a) over Hayashi et al. in view of Berti et al.

The Examiner rejected claims 60-67 under 35 U.S.C. § 103(a) as being unpatentable over Hayashi et al. (U.S. Patent No. 5,482,895) and further in view of Berti et al. (U.S. Patent No. 5,567,651). Applicants respectfully traverse the Examiner's rejections. However, to move the case towards issuance, Applicants have amended claim 60 to indicate that the metal nitride layer is used as an etch stop when etching the cobalt.

To establish a *prima facie* case of obviousness, three basic criteria must be met. First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings. Second, there must be a reasonable expectation of success. Finally, the prior art references must teach or suggest all the claim limitations. See M.P.E.P. § 2143.

Claim 60 is not *prima facie* obvious in view of the cited references as such references do not teach or suggest all the claim limitations and there is no suggestion or motivation to combine the teachings of such references.

Claim 60 describes an etching method for use in integrated circuit fabrication that includes providing a substrate assembly that includes a metal nitride region and a cobalt region.

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The cobalt region is selectively etched against the metal nitride region using a solution comprising a mineral acid and a peroxide. The selective etch of the cobalt region includes using the metal nitride region as an etch stop.

The cited references do not describe such selective etching, nor the use of the metal nitride region as an etch stop. In fact, Berti et al. describes the etching of both the cobalt and the metal nitride (i.e., the metal nitride actually being on top of the cobalt being etched). Hayashi et al. does nothing to provide such lacking elements.

For the above reasons, claim 60 is not obvious in view of the cited references. Further, claims 61-67, which depend, either directly or ultimately, from claim 60 and therefore include all the limitations thereof, are not *prima facie* obvious in view of the cited references for the same reasons as presented above for claim 60. In addition, claims 61-67 each recite additional elements that further support patentability when combined with claim 60.

For example, claim 64 teaches that the solution includes a ratio in a range of about 1:1:300 (mineral acid:peroxide:deionized water) to about 1:1:70 (mineral acid:peroxide:deionized water). The combination of Hayashi et al. and Berti et al., on the other hand, does not teach or suggest such ratios. In addition, claim 66 recites that the cobalt region is selectively etched against the metal nitride region at an etch rate in a range of about 50 Å/minute to about 500 Å/minute. Berti et al. discloses an etching time of 30 minutes for both cobalt and TiN and an implicit etch rate that is clearly lower than 15 Å/minute. In other words, if the entire described thickness of TiN and Co in Berti were considered (i.e., 450 Å), the etch rate for both thicknesses would be only 15 Å/minute. Following silicidation, the unconsumed cobalt is removed. However, it is indicated that at least a portion (and usually a substantial portion to reduce the amount of unreacted Co to be removed) of the Co is consumed during the silicidation process. Therefore, the 15 Å/minute etch rate is clearly lower. In other words, the etch rates taught by Berti et al. are much slower than the etch rates recited in claim 66. Because this combination of references does not teach all the elements of claim 66, such claim is not *prima facie* obvious in light thereof.

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For at least the above reasons, Applicants submit that claims 60-67 are not *prima facie* obvious in view of the cited references. Reconsideration and withdrawal of this rejection are, therefore, respectfully requested.

Allowable Subject Matter

Applicant acknowledges the allowance of claims 68-88.

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It is respectfully submitted that the pending claims are in condition for allowance and notification to that effect is respectfully requested. The Examiner is invited to contact Applicants' Representatives, at the below-listed telephone number, if it is believed that prosecution of this application may be assisted thereby.

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CERTIFICATE UNDER 37 CFR §1.8:

The undersigned hereby certifies that this paper is being transmitted by facsimile in accordance with 37 CFR §1.6(d) to the Patent and Trademark Office, addressed to Assistant Commissioner for Parents, P.O. Box 1450, Alexandria, VA 22313-1450, on this 29th day of August, 2003, at 1:47pm (Central Time).

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